LEVEL III

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IMPROVED PROCEDURES FOR DETERMINING
SEISMIC SOURCE DEPTHS FROM DEPTH
PHASE INFORMATION

QUARTERLY REPORT
1 Apr – 30 Jun 78

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To compensate for sparse coverage of the AI events by the SRO/ASRO and SDCS networks, the depth determination program has been modified to process seismic array data. This will substantially increase the proportion of AI events that can be processed. A total of 28 events were examined during this quarter; 14 of these could not be processed due to inadequate data. Of the remaining 14 events, depth estimates were obtained on 6 of them, 4 were found — next page

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to be outside the 10-80 km depth range examined, and 4 are in secondary processing.

SUBJECT: Improved Procedures for Determining Seismic
            Source Depths from Depth Phase Information

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INTRODUCTION AND SUMMARY

During this quarter, a total of 28 events from the Area of
Interest (AI) data set were examined, and the source depth
determination program was modified to process seismic array
data. The use of array data has turned out to be necessary
because most events in the AI data set have sparse coverage
on the SRO and SDCS networks, making it impossible to base
our analysis entirely on SRO and SDCS as originally planned.
Array data was initially processed by treating each array
element as an individual station. However, this is of ques-
tionable validity, since it results in many stations that
have the same Δ and are also likely to have similar non-depth-
phase cepstrum features, which will then tend to reinforce
and give spurious depth plot peaks. A later program change
allows data from up to 30 stations to be processed at once,
thus permitting array and individual station data to be ana-
lyzed together. One station can then be chosen from each
array and reprocessed with the individual station data to
give an unbiased result.

Of the 28 AI events examined, 14 could not be processed due
to inadequate coverage at teleseismic distances. Depth esti-
mates were made on 6 of the remaining 14 events, no depths
were obtained on 4 of them, and 4 events are in secondary
processing.

MAJOR ACCOMPLISHMENTS

PROCESSING OF SEISMIC ARRAY DATA

Coverage of AI events by stations in the SRO/ASRO and SDCS
networks has been poor, with very few events having as many

as three stations with visible P waves. Since the perfor-
mance of our depth determination technique depends on detect-
ing depth phases for many different stations and primary
phases, better coverage is necessary before depth estimates
can be made on a significant proportion of the AI events.
The obvious solution to this problem is to use data from
other sources, namely, data from the different seismic arrays.

Originally, array data was processed by reading the seismo-
grams from each array element and treating them as separate
stations. This approach turned out to be unsatisfactory,
since each array element will have the same Δ, and thus the
same depth phase delay times at each trial depth. This allows
any cepstrum features that occur consistently at the same
delay time for several array elements to sum into the depth
plots like true depth phase peaks. These constant-delay-
time features are likely to be present in a set of array ele-
ment seismograms and will result in spurious peaks on the
final depth plots. (In a data set with a large range of Δ's,
any constant delay time cepstrum features would be smeared
out by the expected variation of depth phase delay time with
Δ, and would not produce a strong depth plot peak.) Also,
the significance level algorithm assumes that the stations
have a wide range of Δ's, and is not useful when a large num-
ber of stations with the same Δ are used.

To get around this difficulty, the depth determination pro-
gram has been modified to handle a maximum of 30 stations.
This allows the analyst to process all the available data,
including individual stations and array elements, in a single
run. Then, one element can be chosen from each array and re-
run with the single station data to get depth plots that are
not biased in favor the arrays. The initial "all available
seismograms" run takes advantage of the possible reductions
in random noise resulting from using all the array elements,
while the second "single element" run eliminates any spurious
features arising from the duplicate Δ's of the array elements.

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AI EVENT PROCESSING

A total of 28 events from the AI data set have been examined, but 14 of them could not be run through the depth determination program due to inadequate data. An event is considered to have inadequate data if it does not have a visible P wave arrival on at least two stations at teleseismic distances. Close-in data is not acceptable because our depth determination technique is presently based on teleseismic phases; the use of close-in data may be valid with some modifications, but a whole new research project would be necessary to determine this. A minimum of two stations is required because the technique needs repeated depth phases to get a well-defined depth estimate -- even with two stations, a significant depth plot peak can only rarely be obtained. Of the 14 rejected events, 8 had visible P waves on only one station, 3 had no visible P wave arrivals, and 3 were not teleseismic.

Results from 10 of the useable events are shown in Table 1; the remaining 4 events are in secondary processing and have not been listed. In determining the number of stations, each array counts only as one station, not as the number of array elements. For the 4 events with the depth listed as "none," no significant depth plot peaks were detected. Since these events had adequate data to arrive at a depth estimate, this means that the source depth is outside the search interval of 10-80 km.

The reliability of each depth estimate is given as a letter grade. For the events with the depth listed as "none," this grade is an estimate of the probability that the source depth is outside the 10-80 km range. To aid in the evaluation of the discrimination capability of this depth determination technique, these reliability grades will be converted to numerical probabilities in the final report, although they will still be basically qualitative.

TABLE 1. AI PROCESSING RESULTS

EVENT NO.	NO. OF STATIONS	DEPTH (km)	RELIABILITY
1	5	36	F
14	4	20	F
16	3	31	Q
17	2	32	P
19	7	34	G
20	6	NONE	F
21	2	NONE	VP
22	4	NONE	VP
41	3	NONE	Q
50	10	19	G

RELIABILITY GRADES:

G = Good

F = Fair

P = Poor

VP = Very Poor

Q = Questionable

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